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VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 12° TRIM AND WITH A $22\frac{1}{2}^{\circ}$ ANGLE OF DEAD RISE

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RESTRICTED BULLETIN

VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 12° TRIM AND WITH A $22\frac{1}{2}^{\circ}$ ANGLE OF DEAD RISE

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SUMMARY

Tests were made in the Langley impact basin to determine the relationship between impact normal acceleration and flight-path angle for seaplanes landing on smooth water. The tests were made at varying resultant velocities with the model at 12° trim. The model had a $22\frac{1}{2}^{\circ}$ angle of dead rise and a total weight of 1100 pounds. The results of the tests indicated that the maximum impact normal acceleration was proportional to $\gamma^{1.22}$ over the test range of flight-path angle γ and that maximum impact normal acceleration occurred prior to or at the instant of chine immersion.

INTRODUCTION

The initial phase of the research program at the Langley impact basin has been centered upon determining the variation of hydrodynamic impact loads with the principal flight parameters: velocity, flight-path angle, and trim. The variation of impact normal acceleration with resultant velocity is presented in reference 1. The variation with flight-path angle and trim is being determined from data secured by making a series of runs at a fixed trim and varying flight-path angles and then repeating the runs for a different trim. Reference 2 presents data obtained for 3° trim and reference 3, for 6° and 9° trim. The present report gives data obtained in a similar manner at 12° trim.

The present tests were made over a larger range of flight-path angle than those of references 2 and 3 in

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order to secure values indicative of rough-water landings. This increased range of flight-path angle also permitted observations regarding the effect of chine immersion on the impact normal acceleration.

SYMBOLS

V	resultant velocity of float, feet per second
V_h	horizontal velocity component of float, feet per second
V_v	vertical velocity component of float, feet per second
g	acceleration of gravity (32.2 ft/sec^2)
F_{i_w}	impact force normal to water surface, pounds
W	total model weight, pounds
$n_{i_{w_{max}}}$	maximum impact load factor $\left(\frac{F_{i_w}}{W}\right)$
τ	float trim, degrees
γ	flight-path angle, degrees $\left(\tan \gamma = \frac{V_v}{V_h}\right)$
y	vertical displacement of float, inches

EQUIPMENT AND INSTRUMENTATION

The lines and pertinent dimensions of the Langley impact basin float model M-1 tested are shown in figure 1. The model was the forebody of the float described in reference 1 and has a $22\frac{1}{2}^{\circ}$ angle of dead rise with no chine flare. The model was tested at a total weight of 1100 pounds. The test equipment and instrumentation were, with the exception of the accelerometer, the same as those described in reference 1. An NACA air-damped accelerometer with a natural frequency of approximately 21 cycles per second was used to measure impact normal acceleration.

TEST PROCEDURE

The tests included runs at horizontal velocities ranging from approximately 2 feet per second to approximately 100 feet per second, and the vertical velocity ranged from approximately $1\frac{1}{2}$ feet per second to 12 feet per second. The range of flight-path angle resulting from the combination of vertical and horizontal velocities was from approximately 1° to 80°. The trim and angle of yaw were held constant throughout the tests at 12° and 0°, respectively. The depth of immersion was measured at the stern perpendicular to the level water surface. During the impact process a lift equal to the total weight of the model was exerted on the float by means of the buoyancy engine described in reference 1. All test measurements were recorded as time histories.

PRECISION

The apparatus used in the present tests give measurements that are believed correct within the following limits:

Horizontal velocity, foot per second	±0.5
Vertical velocity, foot per second	±0.2
Vertical displacement, inch	±0.2
Acceleration, g	±0.5
Weight, pounds	±2.0

RESULTS AND DISCUSSION

The independent flight parameters, the maximum normal load factor for each impact, and the immersion depth are tabulated for each run in table I. Because the maximum impact normal acceleration was shown in reference 1 to be proportional to the square of the resultant velocity, the hydrodynamic load factor was divided by V^2 to eliminate the effects of velocity. The values of $n_{i_{w_{max}}}/V^2$ thus obtained are plotted in figure 2 against the flight-path angle at the instant of water contact. Within the scatter of the test points the variation of $n_{i_{w_{max}}}$ with γ is a simple power function over the test range. Evaluation of the slope of the curve in figure 2 shows that for 12° trim

$$n_{i_{w_{max}}} \propto \gamma^{1.22}$$

Maximum depth of immersion and depth of immersion at the time of $n_{i_{w_{max}}}$ are plotted against the flight-path angle in figure 3. The distance from the keel to the chine at the stern of the model is 8.0 inches (fig. 1). Since the model was tested at a trim of 12°, an immersion of 7.8 inches would cause the level water line to intersect the chine at the model stern; further immersion would serve to move the water line and chine intersection forward. Figure 3 shows that for flight-path angles up to 15° the maximum impact normal acceleration occurred before a depth corresponding to chine immersion at the stern in level water was reached. For impacts occurring at flight-path angles exceeding 15°, however, the curve leveled off abruptly and the maximum acceleration occurred at a depth corresponding approximately to chine immersion at the stern. Most of the scatter in the test points is believed due to inaccuracies in time correlation between accelerometer and displacement records.

The remaining curve in figure 3 shows that the maximum depth of immersion continues to increase as the flight-path angle increases. Since this curve presents the results of a single instrument, time correlation cannot be a source of error; however, these runs were made at widely different values of Froude number. In the tests of reference 2 different maximum immersions were obtained for similar flight-path angles when the value of Froude number was varied. Since the present test runs were made at varying resultant velocities, the scatter of the test points is believed to be a result of this effect.

It should be noted in figure 2 that there is no apparent change in the variation of $n_{i_{w_{max}}}$ with flight-path angles extending well beyond those resulting in chine immersion.

CONCLUSIONS

Tests were made in the Langley impact basin to determine the relationship between impact normal acceleration and flight-path angle for seaplanes landing on smooth water. The results of the tests, which were made for constant model weight and a model trim of 12°, indicate the following conclusions:

1. The maximum impact normal acceleration was proportional to $\gamma^{1.22}$ over the test range of flight-path angle γ.

2. The maximum impact normal acceleration occurred prior to or at the instant of chine immersion.

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REFERENCES

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2. Batterson, Sidney A.: Variation of Hydrodynamic Impact Loads with Flight-Path Angle for a Prismatic Float at 3° Trim and with a $22\frac{1}{2}^{\circ}$ Angle of Dead Rise. NACA RB No. L5A24, 1945.

3. Batterson, Sidney A., and Stewart, Thelma: Variation of Hydrodynamic Impact Loads with Flight-Path Angle for a Prismatic Float at 6° and 9° Trim and a $22\frac{1}{2}^{\circ}$ Angle of Dead Rise. NACA RB No. L5K21, 1945.

TABLE I

DATA FOR MODEL M-1 TESTED IN LANGLEY IMPACT BASIN

[W = 1100 lb; τ = 12°]

Run	V_v (fps)	V_h (fps)	V (fps)	γ (deg)	$n_{i_{w_{max}}}$	y_{max} (in.)	y at $n_{i_{w_{max}}}$ (in.)
1	1.9	96.4	96.4	1.1	1.1	2.0	1.9
2	3.8	96.6	96.7	2.2	2.4	3.2	3.2
3	4.9	98.2	98.3	2.9	3.1	3.4	3.4
4	11.8	4.3	12.6	69.8	2.4	20.8	7.9
5	12.1	5.1	13.2	66.9	2.4	20.1	7.0
6	11.6	5.6	12.9	64.1	2.5	20.2	7.6
7	12.0	7.6	14.2	57.7	2.6	19.4	8.1
8	11.1	9.7	14.8	48.7	2.6	17.6	7.5
9	11.9	8.8	14.8	53.5	2.6	18.8	7.2
10	12.1	12.5	17.4	43.9	2.8	16.8	7.3
11	12.0	10.5	15.9	48.9	2.7	17.4	7.5
12	11.2	6.9	13.2	58.1	2.5	19.4	7.4
13	11.5	2.3	11.8	78.4	2.4	22.4	6.4
14	12.2	13.6	18.2	41.5	3.0	16.0	7.5
15	12.1	13.7	18.3	41.4	3.0	15.8	7.6
16	11.7	4.4	12.5	69.3	2.5	21.7	7.9
17	11.6	5.7	13.0	63.5	2.5	21.0	7.9
18	11.6	7.9	14.5	55.7	2.5	20.5	8.1
19	10.8	8.3	13.7	52.5	2.6	18.4	8.1
20	11.2	11.5	16.1	52.5	2.7	17.2	6.7
21	11.2	11.8	16.3	43.4	2.8	16.9	9.2
22	10.7	13.0	16.9	39.5	2.8	15.8	6.8
23	11.5	43.1	44.6	14.9	4.4	9.1	7.4
24	11.6	33.4	35.4	20.3	3.9	10.3	7.5
25	11.7	30.6	32.7	20.9	3.5	11.5	8.1
26	12.3	18.9	22.6	33.0	3.0	13.9	8.1
27	11.8	59.5	60.6	11.2	6.7	7.4	6.9
28	7.2	44.8	45.3	9.1	2.7	6.2	4.4
29	2.3	44.6	44.7	3.0	.6	3.3	3.3
30	3.6	45.2	45.3	4.6	1.2	4.2	3.5
31	4.6	44.7	45.0	5.9	1.6	4.6	3.7
32	5.2	44.9	45.2	6.6	1.9	8.0	4.4
33	9.0	45.3	46.2	11.2	3.7	7.5	5.1
34	11.3	45.1	46.5	14.1	5.1	9.0	7.1

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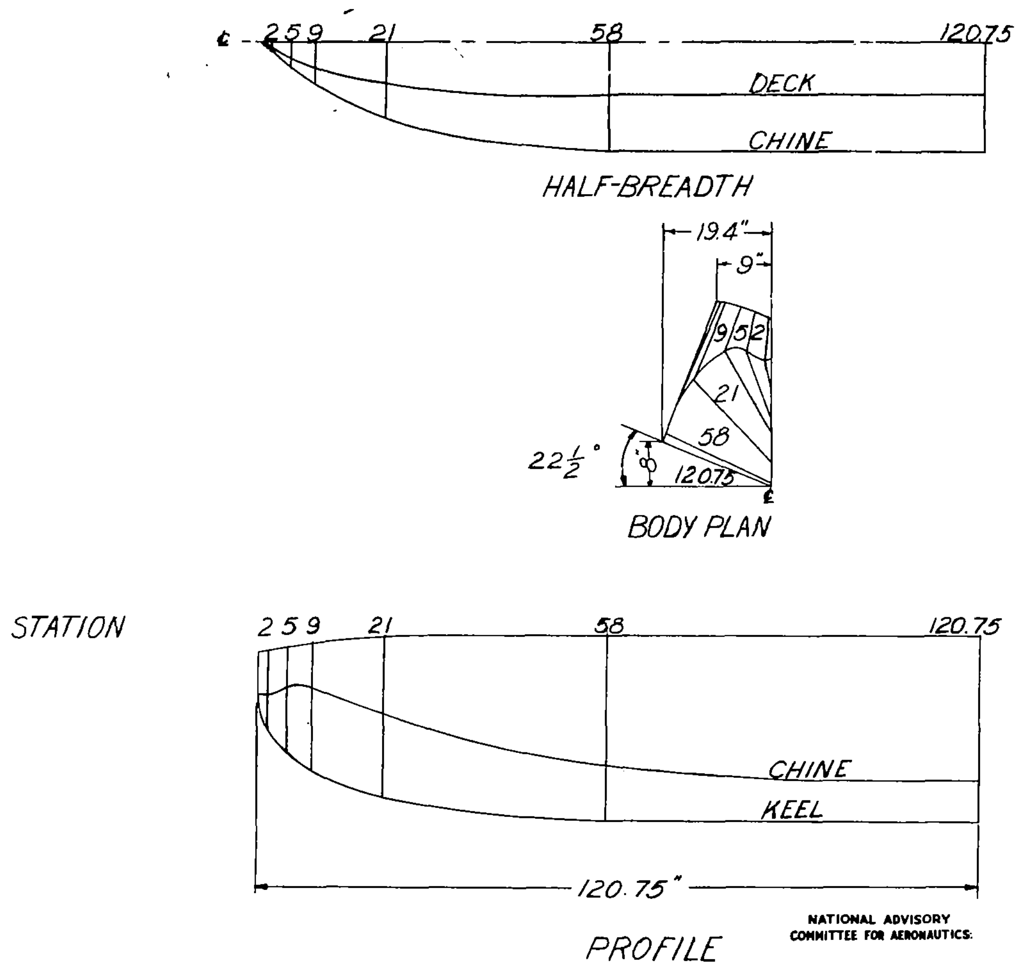

FIGURE 1.- LINES OF FLOAT MODEL M-1 TESTED IN LANGLEY IMPACT BASIN.

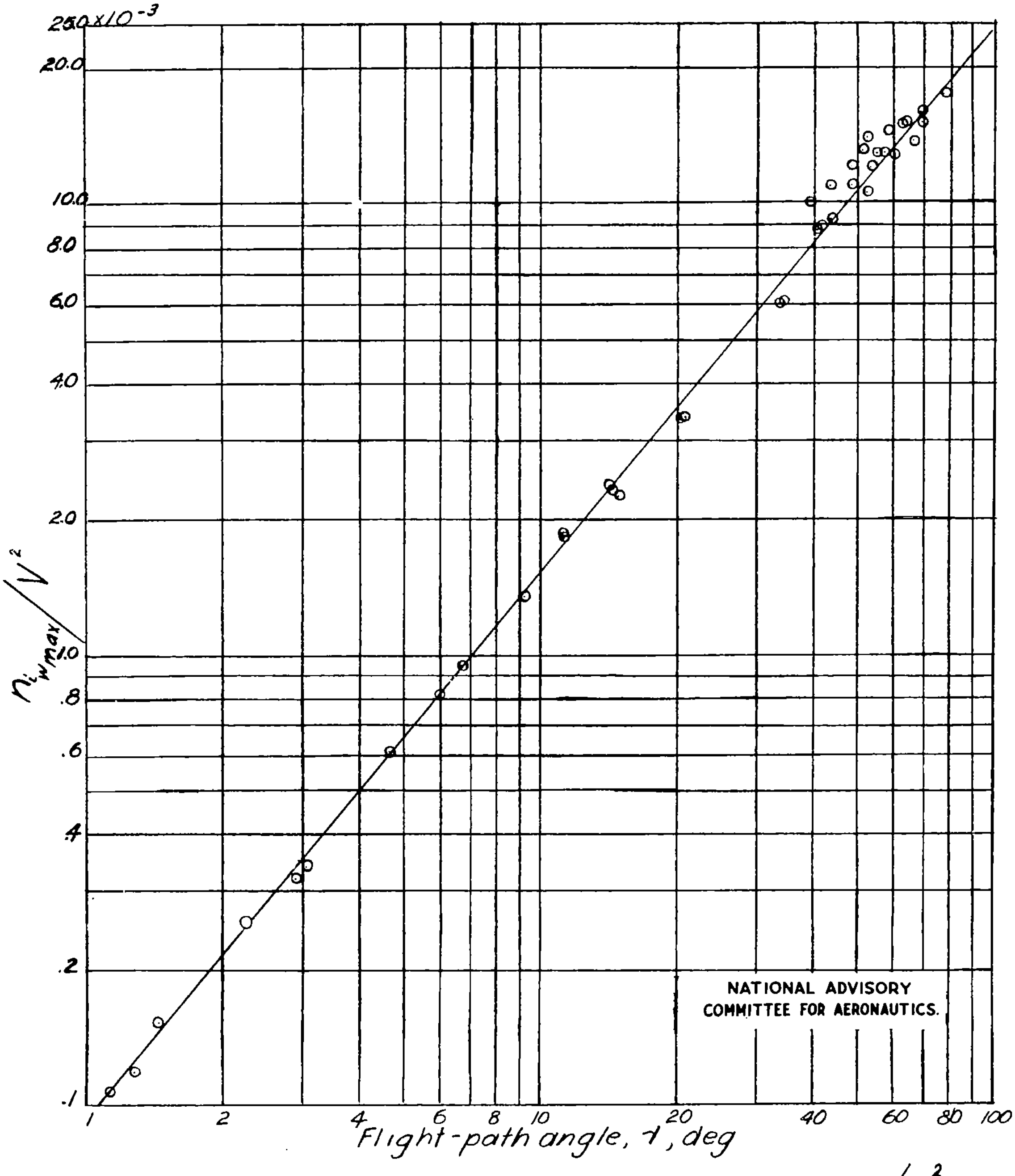

Figure 2.- Variation of the parameter $n_{i_{w_{max}}}/V^2$ with flight-path angle. $\tau = 12°$; W = 1100 pounds.

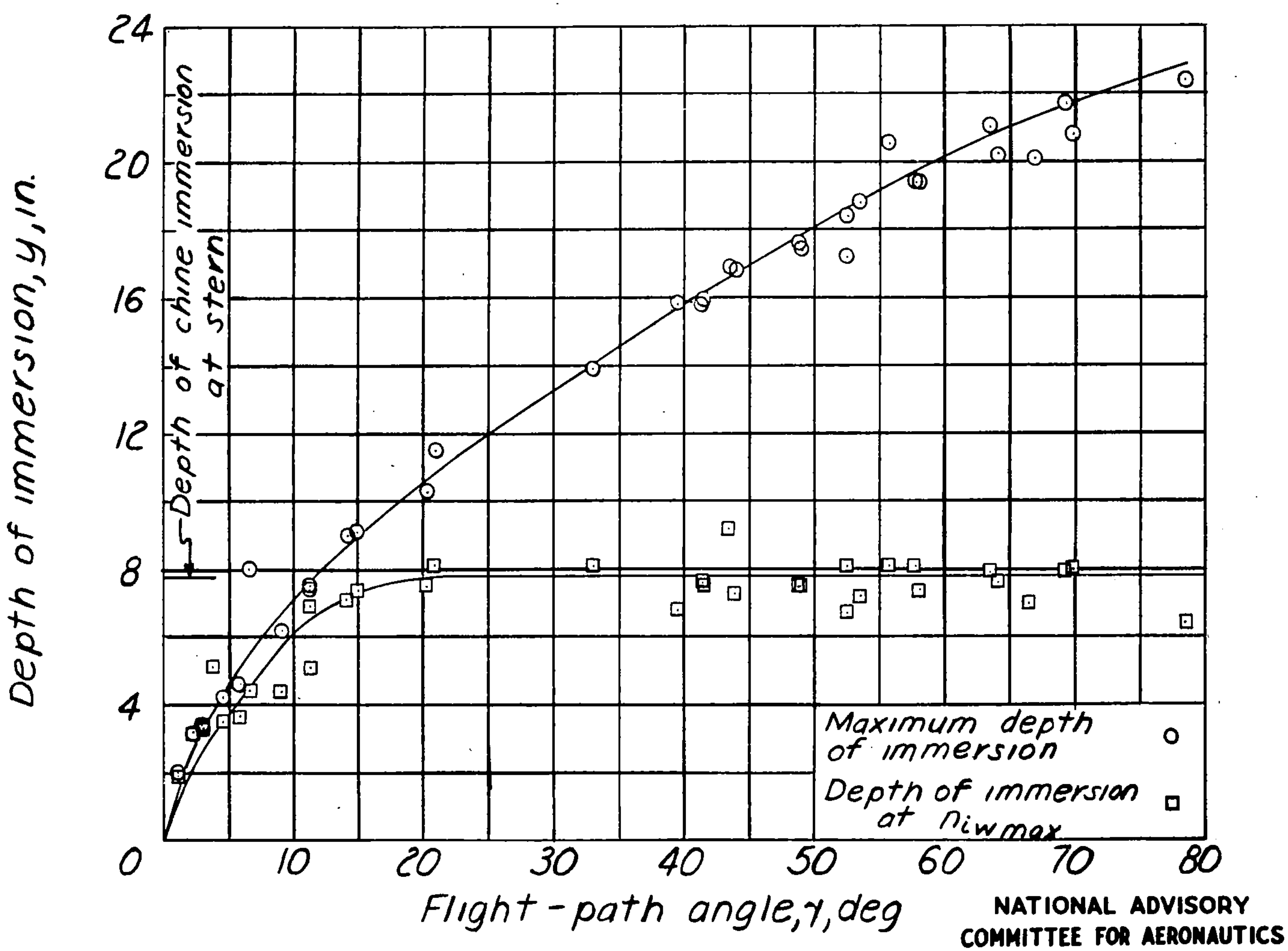

Figure 3.–Variation of maximum depth of immersion and immersion at time of maximum acceleration with flight-path angle. $\tau = 12°$; $W = 1100$ pounds